Lower Duwamish Waterway Slip 4 Early Action Area

LONG-TERM MONITORING DATA REPORT FOR THE SLIP 4 EARLY ACTION AREA: YEAR 7 (2019)

DRAFT

Prepared for

City of Seattle

For submittal to

US Environmental Protection Agency

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Acronyms

2LAET	second lowest apparent effects threshold
ARI	Analytical Resources, Inc.
ASAOC	Administrative Settlement Agreement and Order on Consent
BBP	butyl benzyl phthalate
BEHP	bis(2-ethylhexyl) phthalate
Boeing	The Boeing Company
Cedar Grove	Cedar Grove Composting
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
City	City of Seattle
COC	chain-of-custody
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSL	cleanup screening level
DeNovo	DeNovo Seattle LLC
DSOA	Duwamish Sediment Other Area
dw	dry weight
EAA	Early Action Area
Ecology	Washington State Department of Ecology
EE/CA	engineering evaluation and cost analysis
Emerald Services	Emerald Services Inc.
EOF	emergency overflow
EPA	US Environmental Protection Agency
FWAAC	flow-weighted annual average concentration
GTSP	Georgetown Steam Plant
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
I-5	Interstate 5
ID	identification
ISGP	industrial stormwater general permit

KCIA	King County International Airport
LAET	lowest apparent effects threshold
LDW	Lower Duwamish Waterway
LTMRP	long-term monitoring and reporting plan
LTST	long-term stormwater treatment
MLLW	mean lower low water
MTCA	Model Toxics Control Act
NBF	North Boeing Field
NPDES	National Pollutant Discharge Elimination System
OC	organic carbon
PAH	polycyclic aromatic hydrocarbon
PARIS	permitting and reporting information system
PCB	polychlorinated biphenyl
PSEP	Puget Sound Estuary Protocols
QAPP	quality assurance project plan
QA/QC	quality assurance/quality control
RACR	removal action completion report
RI/FS	remedial investigation/feasibility study
RNA	Regulated Navigation Area
SCO	sediment cleanup objective
SMS	Washington State Sediment Management Standards
SPU	Seattle Public Utilities
SQS	sediment quality standard
SVOC	semi-volatile organic compound
SWPPP	stormwater pollution prevention plan
TEQ	toxic equivalent
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TSS	total suspended solids

VOC	volatile organic compound
Waste Management	Waste Management National Services
Windward	Windward Environmental LLC
ww	wet weight

1 Introduction

This report presents the results of the Year 7 (2019) long-term monitoring of the Slip 4 Early Action Area (EAA) cleanup in the Lower Duwamish Waterway (LDW) Superfund site in Seattle, Washington (Figure 1-1). Year 7 monitoring was conducted on August 1, 2019, by Windward Environmental LLC (Windward) in accordance with the long-term monitoring and reporting plan (LTMRP) (Integral 2013a).

1.1 BACKGROUND

On February 2, 2012, the City of Seattle (City) completed a non-time-critical removal action in Slip 4 to address sediment contaminated with polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), metals, and other organic compounds (Integral 2012). Details of the construction activities are summarized in the removal action completion report (RACR) (Integral 2012). The primary construction activities included:

- Dredging and excavation of 10,256 CY of contaminated bottom sediment and bank soil
- Transloading and disposal of 17,334 tons of soil, sediment, and debris in a Subtitle D landfill, including approximately 130 tons of creosote-treated timbers and piles
- Demolition of 20,019 ft^2 of concrete pier structure
- Recycling of 3,278 tons of concrete and 79 tons of steel
- Construction of stable slopes, sediment caps, and slope caps over 3.43 ac using 53,006 tons of clean material
- Construction of engineered soil covers and expanded habitat in former upland areas

The properties adjacent to Slip 4 are currently owned by The Boeing Company (Boeing) (Parcel 0022000005), First South Properties LLC (First South) (Parcel 2924049043), and 8th Avenue Terminals, Inc. (8th Avenue Terminals) (Parcel 2136200641). The Boeing property's use is presently listed as "heavy industrial." The First South property's use is listed as "general purpose industrial," and it is operated by Cedar Grove Composting Inc. and Cedar Grove Organic Recycling LLC (Cedar Grove) for the distribution of compost products and yard waste recycling. The 8th Avenue property is listed as a "marine/commercial fishing terminal" (King County 2008). The 8th Avenue Terminals property was formerly owned by Crowley Marine Services (1987 to 2014), then by DeNovo Seattle LLC (DeNovo) (2014 to 2019); during that time, it was leased to Waste Management National Services (Waste Management), which operated a soil/sediment transloading facility (referred to as "Duwamish Reload") for the transfer of sacks of contaminated soil and sediment from barges to railcars. The property was sold in

March 2019 to 8th Avenue Terminals, which owns the property where Crowley Marine Services is currently registered to operate (Figure 1-2).

There are three active public outfalls to Slip 4: the Interstate 5 (I-5) storm drain, the Georgetown storm drain, and the King County International Airport (KCIA) storm drain No. 3/PS44 emergency overflow (EOF) (Figure 1-2). In addition, there are eight active private storm drains associated with adjacent properties within Slip 4, two of which are located within the Slip 4 EAA. Figure 1-3 shows the entire 490-ac drainage basin for Slip 4, including the drainage basins of the three public outfalls and the private storm drains. The I-5 storm drain collects runoff from 1.5 mi of I-5 (75 ac), 44 ac of residential property east of I-5, and 1 to 2 ac on the north end of KCIA (Ecology 2006). The Georgetown storm drain was installed in 2009 to replace the Georgetown Steam Plant (GTSP) flume; it drains the roof of the GTSP building and a few catch basins located between that structure and Slip 4. The KCIA storm drain No. 3/SP44EOF drains the northern portion of KCIA and encompasses 290 ac of the Slip 4 drainage area (Ecology 2006). The individual drainage basins for each outfall discharging to Slip 4 are shown on Map I-17 of the *Lower Duwamish Waterway Remedial Investigation*, Appendix I (Windward 2010).

Prior to construction activities, source control actions were completed based on the results of the Slip 4 engineering evaluation and cost analysis (EE/CA) (Integral 2006). Actions taken to reduce the potential for recontamination in Slip 4 by stormwater discharge included:

- Replacement of the GTSP flume with a 12-in.-diameter closed pipe in 2009 (the majority of stormwater from this area is now managed through on-site infiltration (Integral 2011))
- An interim action (completed in 2011), which included the excavation of contaminated soils from the North Boeing Field (NBF) and GTSP properties (Integral 2011)
- Installation of a long-term stormwater treatment (LTST) system by Boeing in 2011

Additional source control activities since the 2012 cleanup have also been conducted by Boeing, the Washington State Department of Ecology (Ecology), Seattle Public Utilities (SPU), the City, Waste Management, and Cedar Grove. These activities are discussed further in Section 2.5.

1.2 SUMMARY OF LONG TERM MONITORING

Overall, the intent of the monitoring program is to verify that the remedy remains protective of human health and the environment by addressing the following LTMRP questions (Integral 2013a):

- Are contaminant concentrations in Slip 4 EAA surface sediments (0 to 10 cm) less than applicable sediment quality standards (SQS)?
- Is the physical integrity of the sediment cap in the Slip 4 EAA being maintained such that the cap continues to isolate contaminants in underlying sediments from marine biota?
- Do the institutional controls associated with the Slip 4 EAA remedy remain in place and continue to work effectively?
- Are physical changes occurring related to sediment erosion and sediment deposition in the Slip 4 EAA?

Table 1-1 provides the complete long-term monitoring schedule.

Table 1-1. Long-term monitoring schedule

	Year to be Performed									
	1	2	3	4	5	6	7	8	9	10[a]
Monitoring Activities	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Visual inspections[b]	X	X	X	X	X		X			X
Institutional control update	X	X	X	X	X		X			X
Review of physical construction/ investigations by other parties	X	X	X	X	X		X			X
Review of storm flow monitoring data for 100-year events	X	X	X	X	X		X			X
Hydrographic surveys[c,d]					X					X
Topographic surveys[e]										
Sediment sampling[d]										
Composite slope cap samples (2)[f]	X		X		X		X			X
Discrete waterway cap samples (6)[f]	X		X		X		X			X
Discrete boundary area documentation samples (2)[g]	X									

[a] Monitoring after Year 10 will be determined upon consultation with EPA.

[b] Additional visual inspections will be performed after any significant seismic events (i.e., peak horizontal ground acceleration greater than 0.10 g).

[c] Surveys will use multi-beam echo sounding at intervals not exceeding 20 ft and will use equipment and methods similar to those used for the removal action post-construction survey.

[d] Frequency may increase if warranted based on visual inspection.

[e] Surveys will be performed as needed based on visual inspection reports of significant physical disturbances observed (e.g., bank slope deformation) or after significant seismic events.

[f] 0–10-cm horizon. To be analyzed for all target analytes listed in Table A-1 of the QAPP (Integral 2013b).

[g] 0–10-cm horizon. To be analyzed for PCB Aroclors, TOC, and total solids.

EPA – US Environmental Protection Agency
PCB – polychlorinated biphenyl
QAPP – quality assurance project plan
TOC – total organic carbon

1.3 REPORT ORGANIZATION

The remainder of this report is organized as follows:

- Section 2. Year 7 Monitoring Components
- Section 3. Conclusions and Recommendations
- Section 4. References

Field notes and data, photographs, log books, and backup data are presented in the following appendices:

- Appendix A. Rain Gauge and Tide Data
- Appendix B. Visual Inspection Field Forms
- Appendix C. Visual Inspection Photographs
- Appendix D. Copy of Visual Inspection Logbook
- Appendix E. Surface Sediment Photographs, Collection Forms, Sampling Logbook, and COC
- Appendix F. Year 7 Sediment Chemistry
- Appendix G. Slip 4 Data Rules and Validation Report
- Appendix H. Other Investigations—Boeing
- Appendix I. Other Investigations—8th Avenue Terminals Property
- Appendix J. Other Investigations – Emerald Services
- Appendix K. Other Investigations—City of Seattle Source Control

2 Year 7 Monitoring Components

Five components were included in the Year 7 (2019) long-term monitoring effort and are summarized in this report. These components included a storm flow monitoring review (i.e., whether 100-year storm events occurred during the Year 7 monitoring period [August 1, 2017, through July 31, 2019]), a visual inspection, sediment sampling from slope and waterway cap sampling locations, an institutional control update, and a review of source control activities and investigations performed by other parties. This section presents the results for each of the five components.

2.1 STORM FLOW MONITORING REVIEW

The LTMRP requires an evaluation of rainfall to estimate whether stormwater flows have the potential to erode the Slip 4 EAA cap (Integral 2013a). For the portion of the LDW that includes Slip 4, a 100-year storm event would correspond to 3.85 in. or more of rainfall within a 24-hour period, as measured by the SPU rain gauge (Station 45-S016, Metro King County, East Marginal Way).

Based on rain gauge data for Station 45-S016 for the period of August 1, 2017, through July 31, 2019, obtained from SPU (2019a, b), no 100-year storm events have occurred since the Year 5 (2017) monitoring period. The maximum daily total rainfall was 1.81 in. (recorded on April 14, 2018). Consequently, no further evaluation of potential stormwater-induced erosion to the cap was necessary. Rain gauge measurements from August 2017 through July 2019 and predicted tide data from the 2018 and 2019 calendar years (SPU 2019a, b; NOAA 2019) are provided in Appendix A.

2.2 VISUAL INSPECTION

A visual inspection of Slip 4 was conducted on August 1, 2019, between 8:20 AM and 1:30 PM, just before and just after a low tide level of -2.99 ft mean lower low water (MLLW).[1] The visual inspection for the Year 7 (2019) monitoring was conducted in accordance with the LTMRP and quality assurance project plan (QAPP) (Integral 2013a, b). No deviations from the QAPP occurred during the Year 7 (2019) visual monitoring event. The inspection was conducted within the survey areas shown on Figure 2-1.

The inspection documented the general condition of the cap, with a focus on any obvious changes in bathymetry/topography resulting from erosion or sedimentation processes, any signs of visible cap breaches (loss of integrity), and any changes to the condition of constructed habitat features (e.g., integrity of anchored woody debris). During the survey, both the depth of accumulation of fine sediment on the cap and the stratification of substrate were evaluated by inserting a ruler into the substrate until

[1] Low tide occurred at 11:52 AM based on the predicted tide curve for the 8th Avenue South tide station (9447029). The tide table for this station is included in Appendix A.

sand and/or gravel cap material was encountered, and then hand-digging around the ruler to expose the substrate profile. Table 2-1 provides a summary of the observations made within each survey area; the original field forms are provided in Appendix B.

Table 2-1. Year 7 visual inspection summary conducted on August 1, 2019

Survey Area	Time	Area Substrate Classification	Estimated Thickness of Fines	Stratification	Surface Sediment Color(s)	Evidence of Pollution	Organic Matter	Observed Debris/Litter/Garbage/Other	Assessment of the Re-establishment of Intertidal Aquatic Habitat	Wildlife Use Observations	Observations of Cap Disturbance/ Erosion/Changed Condition	Assessment of Cap Integrity
Northeast beach	13:12	cobble, gravel, sand	none observed	riprap around action area perimeter, cobble/gravel/mostly sand at surface	gray, brown	none observed	woody debris, leaf litter, sticks	plastic debris, plastic bottles, milk jug, wooden stakes, permanent marker	not applicable (not intertidal)	insects (bees, flies, dragonfly)	none observed	good
Northwest beach	11:40	gravel, sand	none observed	riprap near edges and some within beach area, mostly sand with some gravel mix	gray, brown	none observed	sticks, drift wood, leaf/ plant litter	bottle cap, wooden board, tin foil, rusted metal debris, plastic bottle and debris, balloon, trash	not applicable (not intertidal)	insects (bees, flies), goose feather	none observed	good
North slough	10:06	cobble, gravel, sand, silt/clay, organic matter	up to 26 cm	rounded gravel w/occasional riprap, numerous fines deposition areas, large quantities of organic matter mixed in substrate to 16 cm deep within main channel	black, brown, brown surface	none observed	leaf litter, sticks, areas of heavily deposited organic matter to 16 cm deep, filamentous algae	coir wattle at southeast end of slough channel	barnacles on riprap	flies, dead shore crab, red-eared slider turtle	none observed	good
Central slough	10:53	cobble, gravel, sand, silt/clay, organic matter, wood/shell fragments	up to 41 cm	cobble, gravel and riprap w/sand 1–2 cm deep, silt/clay below	gray, black, brown surface	none observed	leaf litter, sticks, filamentous algae	plastic debris, strips, and bottle, wood plank, ceramic debris	barnacles on riprap	insects (bees, flies) ducks (2 mallards)	none observed	good
South slough	10:45	cobble, gravel, sand, silt/clay, organic matter	up to 37 cm	riprap, cobble, gravel, and sand at surface w/ sand/clay underneath, organic matter sporadic throughout	gray, black brown, brown surface	none observed	leaf litter, filamentous algae, sticks, driftwood	none observed	barnacles on riprap	minnows, flies, crow, green heron	none observed	good
North sediment cap	09:54	cobble, gravel, silt/clay	up to 9 cm	mostly gravel and cobble with some riprap on surface, silt in areas of deposition	black, brown surface	none observed	leaf litter, sticks, driftwood	wooden stake	barnacles on riprap, small amount of western grasswort growing in fines deposition areas	flies, dead shore crab, bird droppings	none observed	good
Northwest sediment cap	11:10	cobble, gravel, sand, silt/clay, organic matter	up to 27 cm	rounded gravel, with fines/sand underneath and some pockets of fines at surface	black, brown surface	none observed	leaf litter, sticks, filamentous algae, pine cones, driftwood	none observed	barnacles on riprap, western grasswort growing in fines deposition areas on mounded/higher elevation portions	bird tracks, flies, dead shore crab	none observed	good
East sediment cap	09:26	cobble, gravel, sand, silt/clay, wood fragments	0.5–11 cm	a few pieces of riprap, mostly cobble and gravel on surface, coarse/medium sand underneath beginning at surface in some areas	gray, black, brown, brown surface	none observed	leaf litter, sticks, driftwood, decaying organic matter at surface, filamentous algae	plastic debris	barnacles on riprap and cobble, western grasswort growing in some fines deposition areas	insects (flies, pill bug), bird droppings and tracks, crows (2), dead shore crab	none observed	good

Table 2-1. Year 7 visual inspection summary conducted on August 1, 2019

Survey Area	Time	Area Substrate Classification	Estimated Thickness of Fines	Stratification	Surface Sediment Color(s)	Evidence of Pollution	Organic Matter	Observed Debris/Litter/Garbage/Other	Assessment of the Re-establishment of Intertidal Aquatic Habitat	Wildlife Use Observations	Observations of Cap Disturbance/ Erosion/Changed Condition	Assessment of Cap Integrity
East-central sediment cap	12:01	cobble, gravel, sand, silt/clay, wood/shell fragments	up to 16 cm	cobble and some riprap on surface, coarse sand at surface in some areas, with fines and sands below	gray, brown, brown surface	none observed	driftwood, filamentous algae, sticks, leaf litter	none observed	barnacles on riprap and cobble	flies, bird droppings	none observed	good
Southeast sediment cap	09:05	cobble, gravel, sand, silt/clay, organic matter, wood/shell fragments	0.5–6 cm in isolated deposition areas	rounded gravel/cobble on surface, medium and coarse sand at surface and below	gray, black, brown, brown surface	none observed	dead kelp, filamentous algae, leaf litter, sticks, decomposing organic matter	piece of metal (handle)	barnacles on cobble, western grasswort growing in fines deposition areas	flies, bird droppings	none observed	good
South sediment cap	12:13	cobble, gravel, sand, silt/clay, wood/shell fragments	up to 25 cm	rounded gravel/cobble with sand/fines mixed below and at surface in depositional areas	gray, black, brown surface	none observed	filamentous algae, leaf litter, sticks	plastic bottle and wrapper	barnacles on cobble, red seagrass on submerged mound of sediment	minnows, bird droppings and tracks, seagull, oyster, oyster with barnacles, flies	none observed	good
West sediment cap	10:21	cobble, gravel, sand, silt/clay, organic matter, wood/shell fragments	up to 18 cm	rounded gravel/cobble, riprap, silt and some sand at surface with mostly sand below	gray, black, brown, brown surface	none observed	filamentous algae, sticks, driftwood	pieces of rusted metal, plastic bottle, paper debris, metal rebar	barnacles on gravel, cobble, and riprap, western grasswort growing in fines deposition areas	minnows, kingfishers (2), bird droppings and tracks, flies	none observed	good
North slope cap (near the outfalls)	11:52	cobble, gravel, sand, silt/clay, organic matter	up to 18 cm (thicker at base of slope)	mostly riprap and rounded gravel/cobble with sand/fines at surface and underneath	black, brown surface	none observed	abundant organic debris including leaf litter, sticks, woody debris, filamentous algae, driftwood	plastic paint roller tray, plastic debris, glass bottle, small gasket, trash bag	barnacles on cobble	flies, bird tracks	none observed	good
Northeast slope cap	13:05	cobble, gravel, sand, wood/shell fragments	up to 5 cm in isolated deposition areas	riprap and rounded gravel/cobble and some sand at surface, sand below	gray, brown	none observed	driftwood, filamentous algae, sticks, leaf litter, woody debris, dead kelp	pillow, plastic debris, wooden stake, Styrofoam, beer can, plastic bottle	filamentous algae and barnacles on riprap near base of slope	insects (flies, bees), bird droppings and feather, oyster shells, dead shore crab	none observed	good
Northwest slope cap	11:25	cobble, gravel, sand, silt/clay	up to 23 cm in isolated deposition areas	riprap w/rounded gravel/cobble to 12 cm deep, coarse sand and fines below in interstices	black, brown surface	none observed	filamentous algae, leaf litter, sticks, driftwood	plastic bucket, bottle, sheeting, and debris, flower bouquet, spray paint can, cigarette butts, construction post, aluminum can	western grasswort growing in fines deposition areas	insects (flies, bees, spider webs between riprap, butterflies) bird droppings and tracks	none observed	good
East slope cap	12:50	cobble, gravel, sand, silt/clay, wood/shell fragments	up to 2 cm (thicker at base of slope)	riprap and large rounded cobble, some sand at surface and below	gray, black, brown, brown surface	none observed	filamentous algae, leaf litter, sticks, driftwood	plastic debris, shoe, string, tin foil, wooden stake, aluminum can	none observed	insects (flies, bees), oyster shell, bird droppings and feathers (goose and other)	none observed	good

Table 2-1. Year 7 visual inspection summary conducted on August 1, 2019

Survey Area	Time	Area Substrate Classification	Estimated Thickness of Fines	Stratification	Surface Sediment Color(s)	Evidence of Pollution	Organic Matter	Observed Debris/Litter/Garbage/Other	Assessment of the Re-establishment of Intertidal Aquatic Habitat	Wildlife Use Observations	Observations of Cap Disturbance/ Erosion/Changed Condition	Assessment of Cap Integrity
Southeast slope cap	08:38	cobble, gravel, sand, silt/clay, organic matter, shell fragments	0.5–5 cm in isolated deposition areas	rounded gravel/cobble on surface with some riprap and medium and coarse sand at surface and below	gray, black, brown, brown surface	none observed	filamentous algae, leaf litter, sticks	tee shirt, cigarette butts, fair amount of garbage accumulation near sign, pop bottle, fishing line, sand bag	barnacles on riprap	insects (flies, small butterflies), seagull carcass, bird droppings (goose and other)	none observed	good
Central sediment cap	10:36	cobble, gravel, sand, silt/clay, wood/shell fragments	up to 29 cm	riprap, cobble, gravel with pockets of sand/silt at surface	gray, brown, brown surface	none observed	trace leaf litter, sticks, driftwood, filamentous algae	metal rebar	barnacles on gravel, cobble, riprap	minnows, oyster, flies	none observed	good

Note: Visual inspection is conducted over a broad survey area (rather than a single point or sediment sample), so that different surface sediment colors, organic matter, and debris/litter/garbage/other can be observed on the sediment surface within each area.

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Accumulated fine sediment was frequently observed in the survey areas. The maximum thickness of observed fines accumulation increased between Year 5 (2017) and Year 7 (2019) in all of the slough areas and sediment cap areas, except for the west sediment cap, where it decreased (Table 2-2). The northeast and northwest beach areas had no observed fines accumulation.

Table 2-2. Thickness of fines in survey areas observed through Year 7 (2019)

Survey Area	2013 Estimated Thickness of Fines[a]	2014 Estimated Thickness of Fines	2015 Estimated Thickness of Fines	2016 Estimated Thickness of Fines	2017 Estimated Thickness of Fines	2019 Estimated Thickness of Fines
Northeast beach	nr	nr	nr	none observed	none observed	none observed
Northwest beach	none observed	none observed	none observed	none observed	none observed	none observed
North slough	up to 1 cm[b]	up to 2 cm	up to 15 cm	2–12 cm	up to 18 cm	up to 26 cm
Central slough	< 1 cm	1–18 cm	1–16 cm	up to 19 cm	up to 24 cm	up to 41 cm
South slough	< 1 cm	up to 5 cm	up to 12 cm	up to 22 cm	up to 25 cm	up to 37 cm
North sediment cap	< 1 cm	< 0.1 cm	< 0.1–3 cm	1–10 cm	up to 8 cm	up to 9 cm
Northwest sediment cap	nr	up to 2.5 cm	1–4 cm	up to 7 cm	up to 12 cm	up to 27 cm
East sediment cap	< 1 cm	up to 0.1 cm	up to 4.5 cm	up to 3 cm	0.5–7 cm	0.5–11 cm
East-central sediment cap	< 1 cm	up to 2 cm	up to 3 cm	up to 12 cm	up to 13 cm	up to 16 cm
Southeast sediment cap	< 1 cm	0.1–0.2 cm in some locations	0.1–0.2 cm	0.5–2.0 cm	0.5–4.0 cm in isolated deposition areas	0.5–6.0 cm in isolated pockets
South sediment cap	< 1 cm[c]	trace, but small areas up to 2.5 cm	up to 2 cm	up to 2 cm	up to 12 cm	up to 25 cm
West sediment cap	up to 1 cm, fines and sand deposits, but ~3 cm thick in some limited areas on slope	up to 9 cm	up to 18 cm observed between gravel hummocks	3–8 cm	up to 20 cm	up to 18 cm
North slope cap (near the outfalls)	none observed	0.1–0.2 cm[d]	up to 6 cm	up to 6 cm (just below riprap)	up to 15 cm (thicker at base of slope)	up to 18 cm (thicker at base of slope)
Northeast slope cap	< 1 cm	< 0.1 cm	< 0.1 cm	< 0.1 cm	< 0.1 cm	up to 5 cm in isolated deposition areas

Table 2-2. Thickness of fines in survey areas observed through Year 7 (2019)

Survey Area	2013 Estimated Thickness of Fines[a]	2014 Estimated Thickness of Fines	2015 Estimated Thickness of Fines	2016 Estimated Thickness of Fines	2017 Estimated Thickness of Fines	2019 Estimated Thickness of Fines
Northwest slope cap	< 1 cm	up to 1 cm	up to 1 cm in isolated deposition areas	up to 2 cm	up to 2 cm in isolated deposition areas	up to 23 cm in isolated deposition areas[e]
East slope cap	< 1 cm	nr	< 0.1 cm	< 0.1 cm	< 0.1 cm	up to 2 cm (thicker at base of slope)
Southeast slope cap	< 1 cm	0.1–0.2 cm	0.1–0.2 cm	0.5–1.5 cm	0.5–1.5 cm in isolated deposition areas	0.5–5 cm in isolated deposition areas
Central sediment cap	nr	nr	nr	area underwater in 2016, so not surveyed	up to 24 cm	up to 29 cm

Sources: Integral (2014a, 2014b, 2015); Windward (2017); (Windward 2018); current survey (2019)

[a] In the Year 1 (2013) monitoring report, the visual inspection summary table was organized by photograph station rather than survey area. Because, in many cases, a survey area is visible from different photograph stations, some survey areas were described multiple times (Integral 2014a). To avoid redundant reporting, Table 2-2 was organized in this report (and in the Year 5 monitoring report) by survey area instead.

[b] The north slough was listed twice in the visual inspection summary table for Year 1 (2013); in one of the entries, it was noted that there were sand deposits several centimeters thick.

[c] The south sediment cap was listed with the northwest slope cap in the Year 1 (2013) visual inspection summary table, and there appears to have been an error in the estimated thickness of fines column for these areas. The data entry stated "< 1 cm on north sediment cap;" it is assumed that this was meant to say "< 1 cm on south sediment cap."

[d] No fine thickness estimates were provided for the "North Slope Cap at Outfalls" entry in the Year 2 (2014) visual inspection summary table; however, estimated fines thicknesses were reported for the "North Slope Cap."

[e] In 2019, an isolated area (near location labeled "E" on Figure 2-1) was observed in the northwest slope cap area with much deeper fines accumulation than was observed elsewhere in that area in previous years. The change in reported thicknesses from ≤2 cm in 2017 to ≤23 cm in 2019 does not likely reflect a 21-cm accumulation of fines between 2017 and 2019 but rather the total accumulation since 2012 in an area not previously evaluated.

ID – identification

nr – not reported

As part of the visual inspection, photographs were taken from established photograph stations (consistent with those used to document post-capping conditions prior to initiation of long-term monitoring surveys (Integral 2013b)). Photographs were taken using a 16-megapixel digital camera (Olympus Stylus TG-860) during the extreme low tide on August 1, 2019 (when Slip 4 EAA sediments were exposed). Photograph stations are shown on Figure 2-1, and Figure 2-2 indicates the orientation of the photographs taken from each station. All photographs taken during the Year 7 (2019) visual monitoring survey are included in Appendix C. Appendix C also presents a comparison of visual inspection photographs from Year 7 to photographs taken from similar vantage points documenting Year 5 (2017), Year 4 (2016), Year 3 (2015), Year 1 (2013),

and baseline conditions (2012) following completion of the EAA remedy, when available. Photograph station coordinates, azimuths, photograph numbers, and target areas are also included in Appendix C.

Photo station locations were established using brightly painted rebar stakes. Most stakes were still upright during the Year 7 (2019) inspection. At Photo Station A (Figure 2-1), a stake was found damaged, bent, and driven mostly into the ground. This stake was replaced with a new marker. At Photo Station I, the survey stake was not found, so field personnel used GPS coordinates to locate the station and re-install a new, painted stake (Appendix C). Visual inspection forms and a copy of the field logbook (Appendices B and D, respectively) were used to record observations of conditions in the areas represented by the photographs (Appendix C).

Key observations from the Year 7 (2019) visual inspection relating to observations from other years included the following:

- There were no observations of adverse impacts on cap integrity (e.g., slope cap sloughing, erosion from outfall discharges, seismic activity, or breaching from vessel activities or other unauthorized physical disturbances). There were also no observations of adverse impacts on the structural integrity of constructed habitat features.
- Vegetative debris (e.g., branches, twigs, trace leaf litter, driftwood) was observed scattered throughout the EAA. Algae growth was observed along the entire intertidal area except in the north sediment cap areas (Table 2-1). Dead kelp was observed in the southeast sediment cap and northeast slope cap areas. A new emergence of western grasswort was observed in numerous intertidal deposition areas of the sediment cap, including the north, northwest, east, southeast, and west sediment cap, as well as the northwest slope cap. Seagrasses were observed in the submerged waters of the south sediment cap.
- Intertidal aquatic habitat was observed establishing itself, with limited barnacle colonies attached to riprap, cobble, and gravel in all areas except for the east and northwest slope cap and the northeast and northwest beach areas.[2] In addition, increased shell fragment dispersion was observed throughout the study area, including the central slough; east-central, southeast, south, west, and central sediment caps; and northeast, east, and southeast slope caps. Filamentous algae was observed in all areas except the north sediment cap and both beach areas.
- Trace litter and plastic debris were observed in most areas (except for the south slough and east, northwest, and east-central sediment cap areas). The northwest beach area had graffiti on some of the riprap. A coir wattle was observed at the

[2] In Year 5 (2017), barnacles were observed in the northwest slope cap area, but they were not observed in Year 7 (2019).

mouth of the north slough, where it transitions into the central slough. The purpose of this wattle is not known.

- Water was seen flowing from an unknown source, potentially a seep, within the riprap, directly beneath the Emerald Services outfall. The Emerald Services outfall was observed to be discharging at a low rate.
- As in previous years, wildlife observations during Year 7 (2019) long-term monitoring comprised mostly avian and insect activity. Commonly observed birds included crows, ducks, kingfishers, and seagulls. Insects observed included primarily flies, bees, butterflies, dragonflies, and pill bugs. Small fish were observed swimming in the south slough and the south, west, and central sediment cap areas. Dead shore crabs were observed in the northeast slope cap, north slough, and north, northwest, and east sediment cap areas. A green heron was seen foraging near the mouth of the south slough, and a red-eared turtle was observed sunning itself near the mouth of the north slough. Oysters were observed in the south and central sediment cap areas, and oyster shells were found in the northeast and east slope cap areas.
- Accumulated fine sediment was frequently observed (Table 2-1), and the maximum thickness of fines accumulation increased between Year 5 (2017) and Year 7 (2019) in most of the cap areas (Table 2-2). The slough areas, as shown in Figure 2-1, were observed to have some of the thickest accumulations (e.g., up to 41 cm in the central slough).
- In the north and south slough areas, leaf litter, sticks, and other types of organic matter were observed to be mixed with the underlying sand and gravel substrate as deep as 16 cm. Abundant organic debris (including leaf litter and sticks) was also observed in the north slope cap area near the outfalls.
- The northwest slope cap, northwest beach, north slope cap near the outfalls, and northeast beach areas were observed to have increased vegetation density. All areas displayed a larger establishment of dune grass, which dominated the vegetated areas. Other species were mixed in as well, such as Pacific aster, wild carrot, sweet pea, wild rose, blackberry, butterfly bush, ivy, snowberry, curly dock, broadleaf dock, honey clover, and a small oak tree (yearling).

2.3 SEDIMENT CHEMISTRY

The purpose of the Slip 4 EAA sediment sampling is to document surface sediment (0 to 10 cm) chemical concentrations. The eight sediment sampling locations occupied during previous monitoring events (Years 1, 3, and 5) were reoccupied in Year 7 (2019). Sampling occurred on August 1, 2019.

As per the LTMRP QAPP addendum (Integral 2016), all of the sediment sampling locations (except for WC-3, WC-7, and WC-8, which were submerged) were formally resurveyed by True North Land Surveying, Inc. on June 26, 2017, prior to the Year 5

(2017) sampling event. Figure 2-3 shows the target and actual sediment sampling locations, and Table 2-3 shows the depths of accumulated fines at each location sampled.

Table 2-3. Depth of accumulated fines material at sediment sampling locations

Sample Location	Thickness of Accumulated Fines	Sample Description
SC-2	0–0.5 cm	This sample was a composite of three sediment samples collected in close proximity to one another (at approximately +4, +8, and +12 ft MLLW) from the northwest slope cap area (Figures 2-1 and 2-3). One sample had 0.5 cm of fines, while the other two had no visible fines. Samples were predominately sand and gravel material.
SC-3	0–2 cm	This sample was a composite of three sediment samples collected in close proximity to one another (at approximately +4, +8, and +12 ft MLLW) from the northeast slope cap area (Figures 2-1 and 2-3). One sample had 2 cm of fines, while the other two had no visible fines. Samples were predominately sand and gravel material.
WC-1	5 cm	The top 5-cm layer consisted of silt and organic material; cap material (large gravel) was present at 5–10 cm, and fines were mixed with gravel throughout.
WC-2	2 cm	A brown, 2-cm-thick surface consisting of fines with organics overlaying gravel cap material was present at 2–10 cm; fine-, medium-, and coarse-grained sand was present within the interstices of the gravel to 5 cm.
WC-3	10 cm	A brown, 1.5-cm-thick surface consisting of fines with organics overlaying gray silt and trace fine sand/trace gravel was present at 1.5–10 cm.
WC-4	1 cm	A brown, 1-cm-thick surface consisting of fines with organics overlaying 9 cm of cap material (large, rounded gravel) was present; dark gray silt with small pockets of rust-colored sediment was present at 2–3 cm, and coarse sand was present at 7–10 cm.
WC-7	10 cm	A brown surface consisting of fines with organics was present at 0.5–1 cm, overlying gray silt with trace fine sands at 1.0–10 cm. The entire 10-cm sample consisted of accumulated material.
WC-8	< 0.5 cm	Trace accumulation of fines (< 0.5 cm) was present on top of 10 cm of mixed gravel cap material, brown silt, and fine sand.

MLLW – mean lower low water

There were no field or laboratory deviations from the QAPP (Integral 2013b). Surface sediment photographs, sediment collection forms, copies of the field logbook, and the chain-of-custody (COC) form are included in Appendix E.

Sediment samples were analyzed following the methods and procedures described in the Slip 4 EAA LTMRP QAPP (Integral 2013b). The analytical methods followed by Analytical Resources, Inc. (ARI) adhered to the most recent US Environmental Protection Agency (EPA) quality assurance/quality control (QA/QC) guidelines. All selected methods represented standard methods used for the analysis of PCBs, semivolatile organic compounds (SVOCs), metals, and conventionals in sediment. The analytical methods used are identified in Table 2-4.

Table 2-4. Laboratory analytical methods and sample handling requirements

Parameter	Analytical Method	Sample Preparation Method	Cleanup Method	Container	Holding Time
Total solids	PSEP (1986)	none	none	wide-mouth glass jar	6 months
Grain size	PSEP (1986)	none	none	wide-mouth glass jar	6 months
TOC	Plumb (1981)	none	none	wide-mouth glass jar	14 days
Mercury	EPA 7471A	none	none	wide-mouth glass jar	28 days
Metals	EPA 6010B	EPA 3050	none	wide-mouth glass jar	6 months
PCB Aroclors	EPA 8082	EPA 3550-B mod	EPA 3665A[a] EPA 3660B[b] EPA3630C[b]	wide-mouth glass jar	14 days until extraction; 40 days after extraction
SVOCs	EPA 8270D	EPA 3550B	EPA 3640A	wide-mouth glass jar	14 days until extraction; 40 days after extraction

[a] Cleanup performed on sediment samples and filter wipe.
[b] Cleanup performed on sediment samples.

EPA – US Environmental Protection Agency
PCB – polychlorinated biphenyl
PSEP – Puget Sound Estuary Protocols
SVOC – semivolatile organic compound
TOC – total organic carbon

EcoChem, Inc. performed independent data validation of all analytical data, which were provided by ARI. A full validation review was conducted, including "best result" selection when samples were analyzed at multiple dilutions. A best result corresponds with the sample with the least dilution that is within the linear calibration range of the analytical instrument. All data, as qualified, were deemed acceptable for use; no data were rejected. Matrix spike and matrix spike duplicate recovery for the mercury analysis were elevated, resulting in all mercury results being J-qualified (i.e., qualified as an estimated concentration) to indicate a potential high bias.

The Year 7 (2019) surface sediment data for the eight sampling locations are presented in Table 2-5. These data were compared to Washington State Sediment Management Standards (SMS) criteria; the specific type of criterion used for the comparison depended on the total organic carbon (TOC) measured in each sample. The results for five of the samples (WC-4, WC-7, WC-8, SC-2, and SC-3), which had TOC between 0.5 and 3.5%, were compared to sediment cleanup objective (SCO) and cleanup screening level (CSL) benthic criteria that are regulated on an organic carbon (OC) basis.[3] The

[3] In Years 1 and 3, an upper threshold of 4% TOC was used instead of 3.5%. The TOC normalization threshold changed through updates to Ecology's Sediment Cleanup Users Manuals.

results for the three other samples (WC-1, WC-2, WC-3), which had TOC greater than 3.5%, were compared on a dry weight basis to the lowest apparent effects threshold (LAET) and second lowest apparent effects threshold (2LAET), in accordance with Ecology (2017). PCB concentrations and SMS exceedances for the Year 7 (2019) sampling locations are provided on Figure 2-4. Complete surface sampling data results for 2019 are provided in Appendix F, and the original laboratory data package from ARI is included in Appendix G.

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Table 2-5. Sediment concentrations compared to SMS criteria

Analyte	Criteria				Units	Sample Location							
						WC-1	WC-2	WC-3	WC-4	WC-7[a]	WC-8	SC-2	SC-3
	Type	Value	Type	Value		Sample ID SL4-SG-WC1-2019	Sample ID SL4-SG-WC2-2019	Sample ID SL4-SG-WC3-2019	Sample ID SL4-SG-WC4-2019	Sample ID SL4-SG-WC7-2019 \ SL4-SG-WC7-FD-2019	Sample ID SL4-SG-WC8-2019	Sample ID SL4-IC-SC2-2019	Sample ID SL4-IC-SC3-2019
Metals													
Arsenic	SCO	57	CSL	93	mg/kg dw	16.5	13.2	18.5	8.74	17.1	11.8	6.85	7.93
Cadmium	SCO	5.1	CSL	6.7	mg/kg dw	1.39	0.749	0.928	0.445	0.750	0.333	0.417	0.605
Chromium	SCO	260	CSL	270	mg/kg dw	46.2	32.5	35.3	25.6	30.9	19.0	44.7	25.2
Copper	SCO	390	CSL	390	mg/kg dw	116	61.1	83.4	34.1	61.3	29.8	30.7	30.0
Lead	SCO	450	CSL	530	mg/kg dw	71.0	35.1	39.1	14.6	26.8	12.2	11.7	13.4
Mercury	SCO	0.41	CSL	0.59	mg/kg dw	0.129 J	0.0923 J	0.183 J	0.0793 J	0.214 J	0.0743 J	0.0452 J	0.0729 J
Silver	SCO	6.1	CSL	6.1	mg/kg dw	0.683 U	0.592 U	0.901 U	0.416 U	0.668 U	0.493 U	0.391 U	0.430 U
Zinc	SCO	410	CSL	960	mg/kg dw	**497**	220	240	97.6	139	75.2	106	120
PAHs													
Benzo(a)anthracene	SCO	110	CSL	270	mg/kg OC	--	--	--	5.37	6.69	4.56	3.67	8.41
	LAET	1,300	2LAET	1,600	µg/kg dw	504	428	174	--	--	--	--	--
Benzo(a)pyrene	SCO	99	CSL	210	mg/kg OC	--	--	--	7.49	6.81	4.76	3.37	9.39
	LAET	1,600	2LAET	1,600	µg/kg dw	572	463	599	--	--	--	--	--
Benzo(g,h,i)perylene	SCO	31	CSL	78	mg/kg OC	--	--	--	6.26	4.11	3.04 J	3.71	9.51
	LAET	670	2LAET	720	µg/kg dw	397	367	230 J	--	--	--	--	--
Total benzofluoranthenes	SCO	230	CSL	450	mg/kg OC	--	--	--	20.1	17.7	14.2	9.14	28.3
	LAET	3,200	2LAET	3,600	µg/kg dw	1,540	1,210	819 J	--	--	--	--	--
Chrysene	SCO	110	CSL	460	mg/kg OC	--	--	--	9.78	11.8	7.95	7.00	23.1
	LAET	1,400	2LAET	2,800	µg/kg dw	1,340	786	715	--	--	--	--	--
Dibenzo(a,h)anthracene	SCO	12	CSL	33	mg/kg OC	--	--	--	0.872 UJ	0.619 UJ	1.31 UJ	2.44 U	3.63 U
	LAET	230	2LAET	230	µg/kg dw	59.6 UJ	59.7 UJ	40.6 J	--	--	--	--	--
Fluoranthene	SCO	160	CSL	1,200	mg/kg OC	--	--	--	21.8	29.1	11.6	15.8	62.8
	LAET	1,700	2LAET	2,500	µg/kg dw	**1,930**	1,530	1,440	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	SCO	34	CSL	88	mg/kg OC	--	--	--	4.89	3.23	2.83 J	2.38 J	8.78
	LAET	600	2LAET	690	µg/kg dw	351	244	153 J	--	--	--	--	--
Phenanthrene	SCO	100	CSL	480	mg/kg OC	--	--	--	4.93	4.63	3.09	3.82	17.4
	LAET	1,500	2LAET	1,500	µg/kg dw	452	331	392	--	--	--	--	--
Pyrene	SCO	1,000	CSL	1,400	mg/kg OC	--	--	--	16.1	21.5	10.1	13.2	40.2
	LAET	2,600	2LAET	3,300	µg/kg dw	1,670	1,270	1,020 J	--	--	--	--	--
Total HPAHs	SCO	960	CSL	5,300	mg/kg OC	--	--	--	91.8	101	59.1 J	58.3 J	191
	LAET	12,000	2LAET	17,000	µg/kg dw	8,300	6,300	5,190 J	--	--	--	--	--

Table 2-5. Sediment concentrations compared to SMS criteria

Analyte	Criteria				Units	Sample Location							
						WC-1	WC-2	WC-3	WC-4	WC-7[a]	WC-8	SC-2	SC-3
	Type	Value	Type	Value		Sample ID SL4-SG-WC1-2019	Sample ID SL4-SG-WC2-2019	Sample ID SL4-SG-WC3-2019	Sample ID SL4-SG-WC4-2019	Sample ID SL4-SG-WC7-2019 \ SL4-SG-WC7-FD-2019	Sample ID SL4-SG-WC8-2019	Sample ID SL4-IC-SC2-2019	Sample ID SL4-IC-SC3-2019
cPAH TEQ	nc	--	nc	--	µg/kg dw	837	671	737 J	245	315	110 J	132 J	244
Phthalates													
Bis(2-ethylhexyl)phthalate	SCO	47	CSL	78	mg/kg OC	--	--	--	32.2	22.0	10.7	44.0	**76.2**
	LAET	1,300	2LAET	1,900	µg/kg dw	**5,850**	**3,590**	**1,640**	--	--	--	--	--
Butyl benzyl phthalate	SCO	4.9	CSL	64	mg/kg OC	--	--	--	0.872 U	0.87 J	1.31 U	0.811 U	1.21 U
	LAET	63	2LAET	900	µg/kg dw	**986**	**243**	42.4	--	--	--	--	--
Di-n-octyl phthalate	SCO	58	CSL	4,500	mg/kg OC	--	--	--	0.872 U	1.61	1.31 U	0.811 U	4.32
	LAET	6,200	2LAET	6,200	µg/kg dw	269	230	20.0 U	--	--	--	--	--
Other SVOCs													
Benzoic acid	SCO	650	CSL	650	µg/kg dw	596 U	597 U	99.9 J	198 U	79.9 J	198 U	197 U	93.6 J
Benzyl alcohol	SCO	57	CSL	73	µg/kg dw	59.6 UJ[b]	59.7 UJ[b]	16.7 J	19.8 UJ	21.5 J	19.8 UJ	19.7 UJ	17.4 J
n-Nitrosodiphenylamine	SCO	11	CSL	11	mg/kg OC	--	--	--	0.872 U	0.619 U	1.31 U	0.811 U	1.21 U
	LAET	28	2LAET	40	µg/kg dw	59.6 U[b]	59.7 U[b]	12.8 J	--	--	--	--	--
Phenol	SCO	420	CSL	1200	µg/kg dw	59.6 UJ	117 J	37.9 J	12.5 J	17.5 J	16.5 J	59.2 U	20.9 J
PCBs													
Aroclor-1016	nc	--	nc	--	µg/kg dw	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U
Aroclor-1221	nc	--	nc	--	µg/kg dw	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U
Aroclor-1232	nc	--	nc	--	µg/kg dw	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U
Aroclor-1242	nc	--	nc	--	µg/kg dw	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U
Aroclor-1248	nc	--	nc	--	µg/kg dw	43.5	43.1	36.4	11.8	35.5	11.1	8.3	8.8
Aroclor-1254	nc	--	nc	--	µg/kg dw	92.1	97.5	72.1	24.7	55.2	17.4	14.3	22.1
Aroclor-1260	nc	--	nc	--	µg/kg dw	52.2	49.1	37.6	14.6	40.7	14.7	11.8	17.3
Aroclor-1262	nc	--	nc	--	µg/kg dw	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U
Aroclor-1268	nc	--	nc	--	µg/kg dw	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U
Total PCB Aroclors	SCO	12	CSL	65	mg/kg OC	--	--	--	2.25	4.08	2.86	1.42	2.94
	LAET	130	2LAET	1000	µg/kg dw	**187.8**	**189.7**	**146.1**	--	--	--	--	--
Grain size													
Total gravel	nc	--	nc	--	% dw	1.1	54.4	1.4	59.6	0.1	67.9	18.7	16.5
Total sand	nc	--	nc	--	% dw	46.0	25.9	21	25.4	9.0	19.4	70.1	66.4
Total silt	nc	--	nc	--	% dw	46.6	15.4	61.9	11.1	72.3	8.4	8.1	13.7
Total clay	nc	--	nc	--	% dw	6.4	4.3	16	3.8	18.7	4.5	3.0	3.4
Total fines (silt + clay)	nc	--	nc	--	% dw	53.0	19.7	78	14.9	91.0	12.9	11.1	17.1

Table 2-5. Sediment concentrations compared to SMS criteria

Analyte	Criteria				Units	Sample Location							
						WC-1	WC-2	WC-3	WC-4	WC-7[a]	WC-8	SC-2	SC-3
	Type	Value	Type	Value		Sample ID SL4-SG-WC1-2019	Sample ID SL4-SG-WC2-2019	Sample ID SL4-SG-WC3-2019	Sample ID SL4-SG-WC4-2019	Sample ID SL4-SG-WC7-2019 \ SL4-SG-WC7-FD-2019	Sample ID SL4-SG-WC8-2019	Sample ID SL4-IC-SC2-2019	Sample ID SL4-IC-SC3-2019
Conventionals													
TOC	nc	--	nc	--	% dw	8.63	4.68	4.98	2.27	3.22 J	1.51	2.43	1.64
Total solids	nc	--	nc	--	% ww	42.54	46.21	32.85	66.66	41.19	57.54	72.09	67.53

For analytes with OC-normalized SMS criteria, OC-normalized results are shown if they were within the TOC range of 0.5 to 3.5%; otherwise, dry weight data are presented for comparison to LAET and 2LAET values.
Detected concentrations in **bold** exceeded the SCO or LAET.
Detected concentrations in **bold underline** exceeded the CSL or 2LAET.

[a] The results of the two field duplicate samples (samples SL4-SG-WC7-2019 and SL4-SG-WC7-FD-2019) collected from station WC-7 were averaged. Both results are presented in Appendix F.

[b] Detection limit is greater than SMS criterion due to sample dilution.

2LAET – second lowest apparent effects threshold
cPAH – carcinogenic polycyclic aromatic hydrocarbon
CSL – cleanup screening level
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
ID – identification
J – estimated concentration
LAET – lowest apparent effects threshold
nc – no criteria
OC – organic carbon
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SCO – sediment cleanup objective
SMS – Washington State Sediment Management Standards
SVOC – semivolatile organic compound
TEQ – toxic equivalent
TOC – total organic carbon
U – not detected at given concentration
ww – wet weight

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In Year 7 (2019), at least one SMS criterion was exceeded at four sediment sampling locations: WC-1, WC-2, WC-3, and SC-3 (Figure 2-4). Total PCBs were detected at concentrations that exceeded the LAET at three sampling locations: WC-1, WC-2, and WC-3 (Table 2-5, Figure 2-4). Bis(2-ethylhexyl) phthalate (BEHP) was detected at concentrations exceeding criteria at all four sampling locations noted with exceedances. Butyl benzyl phthalate (BBP) was detected at concentrations that exceeded criteria at two of the eight sampling locations (WC-1 and WC-2). Fluoranthene and zinc concentrations exceeded criteria (LAET and SCO, respectively) at WC-1. Exceedances observed during previous long-term monitoring events are presented in Figure 2-5.

The average sediment TOC, total PCBs, BBP, BEHP, and high-molecular-weight polycyclic aromatic hydrocarbon (HPAH) concentrations for all four years of monitoring are provided in Table 2-6. The average TOC, BBP, and HPAH concentrations have increased consistently. The average total PCB concentration increased between 2013 and 2015 and decreased between 2015 and 2019. BEHP increased between 2013 and 2017, but decreased in 2019.

Table 2-6. Average Slip 4 sediment concentrations for 2013, 2015, 2017, and 2019

Contaminant	Units	Long Term Monitoring Year			
		Year 1 (2013)	Year 3 (2015)	Year 5 (2017)	Year 7 (2019)
TOC	% dw	2.55	2.63	3.02	3.67
Total PCBs	µg/kg dw	130	172	107	104
BBP	µg/kg dw	28.4	65	102	167
BEHP	µg/kg dw	610	1,390	1,930	1,870
HPAH	µg/kg dw	1,082	1,581	1,763	3,820

BEHP – bis(2-ethylhexyl) phthalate
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
TOC – total organic carbon

2.3.1 Total PCBs

To show trends, dry weight total PCB concentrations are presented in Figure 2-6 for each of the Slip 4 locations from post-construction (2012) to Year 7 (2019). Total PCB concentrations were less in Year 7 (2019) than in Year 5 (2017) at five of the eight locations (WC-1, WC-3, WC-4, WC-7, and WC-8). Total PCB concentrations increased from Year 3 (2015) through Year 7 (2019) at WC-2. Total PCB concentrations were slightly greater at SC-2 and SC-3 in Year 7 (2019) than in past years, but the PCB concentrations in these slope cap locations have been consistently the lowest measured in each of the monitoring events.

Total PCBs were detected at concentrations that exceeded SMS criteria at three locations in 2019 (WC-1, WC-2, and WC-3) (Table 2-5), based on a comparison of PCB concentrations to the LAET because TOC was greater than 3.5% at these locations.

2.3.2 Phthalates

To show trends, dry weight total BEHP concentrations are presented in Figure 2-6 for each of the Slip 4 locations from post-construction monitoring (2012) to Year 7 (2019). BEHP concentrations decreased in Year 7 (2019) compared to Year 5 (2017) for three of the eight locations (WC-1, WC-3, and WC-8). BEHP concentrations increased in Year 7 (2019) for the remaining five locations (WC-2, WC-4, WC-7, SC-2, and SC-3) (Figure 2-6). BEHP was detected at concentrations that exceeded SMS criteria at four locations in Year 7 (2019) (SC-3, WC-1, WC-2, and WC-3) (Table 2-5). All but one of these exceedances is based on a comparison to the LAET.

BBP concentrations at WC-1 have increased since post-construction (2012) through Year 7 (2019). Concentrations also increased between Year 5 (2017) and Year 7 (2019) at WC-2. Concentrations at WC-3 decreased over the same time period (Figure 2-6). BBP was detected at concentrations that exceeded SMS criteria at two locations in Year 7 (2019) (WC-1 and WC-2) based on an LAET comparison (Table 2-5).

2.3.3 Other analytes

Four other analytes (in addition to total PCBs, BEHP, and BBP) have been detected in Slip 4 EAA sediments at concentrations exceeding SMS criteria. Benzyl alcohol was detected at concentrations exceeding SMS criteria at two locations in 2013 (WC3 and WC-7), four locations in 2015 (WC-1, WC-3, WC-7, and WC-8), and one location (WC-3) in 2017; no exceedances were reported in 2019. Benzoic acid was detected at concentrations exceeding SMS criteria once, at location WC-3 in 2013. Fluoranthene was detected at concentrations exceeding SMS criteria once, at location WC-1 in 2019. Zinc was detected at concentrations exceeding SMS criteria at location WC-1 in 2015, 2017, and 2019. Concentrations of fluoranthene and zinc have increased since 2013.

2.4 INSTITUTIONAL CONTROLS REVIEW

The implementation of institutional controls was completed in November 2014 with the final installation of the notification signs at the boundaries of the Regulated Navigation Area (RNA) in the Slip 4 EAA (Integral 2014b). Installed at the mouth of Slip 4 and near the sediment cap boundaries, the notification signs inform vessel operators of the presence and prohibit the disturbance of the sediment cap. The signs were examined as part of the Year 7 (2019) long-term monitoring and found to remain in good condition. The US Coast Guard received no reports of violations of the RNA between August 2017 and July 2019, but two requests from vessels to anchor were denied (USCG 2019).

2.5 REVIEW OF OTHER SOURCE CONTROL ACTIVITIES DURING YEAR 7

This section provides a summary of updates regarding investigations or site activities performed by other parties in or near the Slip 4 EAA during the Year 7 (2019) long-term monitoring period. Ongoing or recently completed source control activities and other monitoring programs within the vicinity of the Slip 4 EAA include:

- NBF remedial investigation/feasibility study (RI/FS) and LTST operation
- Boeing Plant 2 Duwamish Sediment Other Area (DSOA) corrective measure monitoring
- Ongoing National Pollutant Discharge Elimination System (NPDES) stormwater sampling at the Waste Management facility on the 8th Avenue Terminals property, and the Phase 2 Model Toxics Control Act (MTCA) remedial investigation/feasibility study (RI/FS) on the 8th Avenue Terminals property
- Ongoing NPDES stormwater sampling at the Cedar Grove facility on the First South Properties LLC property
- SPU's ongoing source control program for the LDW

Summaries of the investigations performed during the Year 7 long-term monitoring period (August 2017 through July 2019) that were not available before publication of the Year 5 report are presented in the following subsections.

2.5.1 NBF RI/FS and LTST

Work on the RI/FS at the NBF/GTSP site is ongoing. Ecology has requested that a third phase of the RI be conducted in order to further investigate the extent of volatile organic compounds (VOCs) in groundwater in areas bordering the NBF/GTSP site. Boeing and the City anticipate that the RI will be completed in 2020. Once the RI is complete and has been approved by Ecology, work will begin on the FS.

Boeing continues to operate the LTST system, consistent with the plans approved under the Administrative Settlement Agreement and Order on Consent (ASAOC) for Removal Action, EPA Docket No. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) 10-2010-0242. The ASAOC activities were completed on March 2, 2016; however, Boeing continues to operate the system as a treatment best management practice under Ecology's industrial stormwater general permit (ISGP) WAR000226. More than 91% of the capacity of the LTST system goes toward treating stormwater from the Propulsion Engineering Labs area (north end of the NBF Site); the remainder of the treatment capacity is dedicated to the treatment of stormwater from the rest of the NBF site and the north end of KCIA. In 2017, the system treated approximately 64% of the combined stormwater discharges from NBF and the north end of KCIA (241.8 million gal. out of a total of 380.4 million gal.) (Appendix H). In 2018, the system treated approximately 72% of the combined stormwater discharges from NBF and the north end of KCIA (203.1 million gal. out of a total of 283.8 million

gal.) (Appendix H). The remainder of the stormwater bypassed the treatment system and was discharged directly to Slip 4. Concentrations in whole-water samples collected from the compliance monitoring point (LS431) since the implementation of stormwater treatment in 2011 have consistently been less than the marine chronic water quality criterion interim goal of 0.030 µg/L and less than the flow-weighted annual average concentration (FWAAC) goal of 0.018 µg/L. The FWAAC calculations for the LTST system for 2017 and 2018 are provided in Appendix H. The percentage of stormwater treated and FWAAC comparisons for 2020 (the eighth year of LTST system operation) will be calculated in the first quarter of 2020.

2.5.2 Boeing Plant 2 DSOA Corrective Measure

Three surface sediment grab samples (sample locations S16, S17, and S18) were collected from within Slip 4 (but outside of the Slip 4 EAA boundary) by Boeing in 2017 (June) and 2018 (March and October) (Figure 2-7). The depositional layer of material observed in these sediment samples ranged from 6.7 to 20.3 cm. Samples of the depositional material collected from one of the sample locations (S18) in June 2017 and March and October 2018 were analyzed for grain size, TOC, and PCBs; total PCB concentrations ranged from 134 to 173 µg/kg dry weight (dw) and from 4.7 to 5.9 mg/kg OC (Wood 2018).

In March 2018, Boeing collected surface sediment samples from two locations (SD-PCM010 and SD-PCM025) within Slip 4 (but outside of the Slip 4 EAA boundary) as part of its Boeing Plant 2 Year 3 post-construction surface sediment monitoring (Figure 2-7). Analytes included conventionals, metals, PAHs, chlorinated benzenes, phthalates, and PCB Aroclors. The depositional layer of material observed in the sediment samples was 2.5 cm thick for SD-PCM010 and 10 cm thick for SD-PCM025. The detected total PCB concentrations were 112.9 µg/kg dw (4.1 mg/kg OC) for SD-PCM010 and 8.4 µg/kg dw for SD-PCM025; TOC at SD-PCM025 was 0.47%, so OC-normalized total PCB concentrations were not calculated. None of the metals analyzed in Boeing's sediment samples were detected at concentrations greater than their respective SCOs. Appendix H contains a map of the sampling locations, deposition layer measurements, and chemistry data from this study; sediment sampling locations are also shown on Figure 2-7.

2.5.3 The 8th Avenue Terminals property

The 8th Avenue Terminals property (formerly DeNovo) was owned and operated by Crowley Marine Services between 1987 and 2014, then leased to and operated by Waste Management until 2019. Currently, Crowley Marine Services is permitted to operate at the 8th Avenue Terminals property (Figure 1-2). The property is now undergoing an RI/FS under an Agreed Order with Ecology that has been amended to include DeNovo (Ecology 2009, 2014a). A draft RI report was submitted to Ecology in August 2016 and is still under review (Sutton 2017).

During the Slip 4 Year 7 long-term monitoring period (August 2017 to July 2019), Waste Management conducted NPDES monitoring at the 8th Avenue Terminals property (referred to in the Year 5 data report as the "DeNovo property") in accordance with Ecology ISGP WAR302034.[4] Monitoring results available on Ecology's online PARIS database (Ecology 2019) are included in Appendix I. Benchmark exceedances of zinc, copper, and turbidity, as well as effluent violations for residue solids/total suspended solids (TSS), were reported during this period (Ecology 2016). The range of metals concentrations that exceeded benchmarks were 14.3 to 106.5 µg/L copper and 138 to 408 µg/L zinc. Stormwater samples were also analyzed for PCB Aroclors; PCBs were detected in grab samples collected in the fourth quarter of 2017, first and second quarters of 2018, and second quarter of 2019. Detected concentrations of total PCBs ranged from 9.97 to 61.6 ng/L, exceeding Washington State surface water quality criteria for aquatic life (chronic) (14 ng/L in freshwater and 30 ng/L in marine waters) and human health (0.17 ng/L) (173-201A Washington Administrative Code).

2.5.4 Emerald Services

The First South Properties LLC property is operated by Emerald Services and Cedar Grove. During 2017 and 2018,[5] NPDES monitoring was conducted at the Emerald Services facility in accordance with Ecology's ISGP WAR002641 (Ecology 2019). Total nitrate plus nitrite exceeded benchmarks in the second and fourth quarterly grab samples of 2018, and elevated TSS in the fourth quarterly grab sample of 2018 resulted in a numeric effluent violation. Copper and zinc, which exceeded benchmarks during the Year 5 monitoring period, did not exceed benchmarks during the 2017 to 2018 period. PCBs were not analyzed; see Appendix J for details.

2.5.5 City of Seattle

As part of the City's LDW Pollution Source Control Program, in April 2018 and April 2019, SPU collected two sediment trap samples and two inline grab samples at location SL4-T6 from the City storm drain system upstream of I-5 (SPU 2019c), that discharges into Slip 4 via the I-5 SD at Slip 4 shown on Figure 1-3. SPU also collected two inline grab samples at a second location, MH23, from the storm drain that discharges into Slip 4 via the Georgetown SD also shown on Figure 1-3). The data for these samples are provided in Appendix K. Select analytes of interest that were detected in grab and sediment trap samples included total PCBs (19U to 282 µg/kg), BEHP (248 to 15,500 µg/kg), BBP (19.2U to 22,300 µg/kg), HPAHs (174J to 30,343J µg/kg), and zinc (41 to 1,090 mg/kg).

[4] The facility is referred to as "Alaska Logistics LLC" in Ecology's permitting and reporting information system (PARIS) database (Ecology 2014b).

[5] Sampling data collected under ISGP WAR002641 are only available (via the PARIS database) from the fourth quarter of 2017 and the first, second, and fourth quarters of 2018; no data are currently (as of October 2019) available for 2019 (Ecology 2019).

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3 Conclusions and Recommendations

The objectives of the Year 7 (2019) monitoring program for the Slip 4 EAA were achieved. The monitoring results indicated that the sediment cap remains structurally sound, and sediment continues to accumulate on top of the cap. Physical conditions observed during Year 7 (2019) monitoring were similar to those noted in previous monitoring years. Fine sediment deposits were observed throughout the cap areas at varying thicknesses, which had generally increased or remained consistent since Year 5 (2017). The thickest accumulations were generally observed in the slough areas, along the central, northwest, and south sediment cap areas, and along the northwest slope cap.

At least one analyte (BEHP, BBP, PCBs, fluoranthene, and/or zinc) was detected at concentrations exceeding SMS criteria at four of the eight sampling locations(Figure 2-4). The average TOC, BBP, and HPAH concentrations have increased since 2013. The average total PCB concentration increased between 2013 and 2015 and decreased between 2015 and 2019. BEHP increased between 2013 and 2017, but decreased in 2019.

In summary, the results of the Year 7 (2019) monitoring provided the following answers to the LTMRP questions:

- Are contaminant concentrations in Slip 4 EAA surface sediments (0 to 10 cm) below applicable SQS?

  No. In Year 7 (2019), BEHP exceeded its SMS criterion in four samples, BBP exceeded its SMS criterion in two samples, total PCBs exceeded its SMS criterion in three samples, fluoranthene exceeded its SMS criterion in one sample, and zinc exceeded its SMS criterion in one sample.

- Is the physical integrity of the cap in the Slip 4 EAA being maintained such that the sediment cap continues to isolate contaminants in underlying sediments from marine biota?

  Yes.

- Do the institutional controls associated with the Slip 4 EAA remedy remain in place and continue to work effectively?

  Yes.

- Are physical changes occurring related to sediment erosion and sediment deposition in the Slip 4 EAA?

  Yes. Sediment is depositing on and mixing into cap materials in most areas. However, in some areas (e.g., beach areas), neither deposition nor erosion

appear to have occurred, and in others (e.g., southeast sediment cap), deposition is limited to relatively small patches.

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